

Biology and Reproductive Rate of the Leucaena Psyllid, *Heteropsylla cubana* Crawford¹

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ABSTRACT

The biology and reproductive rate of the leucaena psyllid, *Heteropsylla cubana* Crawford, was studied using *Leucaena leucocephala* (Lam.) de Wit as host. Total developmental time was 10-11 days; eggs hatched in 2-3 days and the five nymphal instars required 8-9 days. Mean adult longevity was 10.6 days for females and 6.4 days for males. The preoviposition period ranged from 1-3 days. Mean egg production during the oviposition period was 18.8 eggs per day. The results of the reproductive study indicated a potential for rapid population increase if left unchecked.

The leucaena psyllid, *Heteropsylla cubana* Crawford (Burckhardt 1986) (Fig. 1A, B), was first collected on Oahu in early 1984, and is now found on all major islands of the State (Nakahara and Lai 1984). It damages koa-hao, *Leucaena leucocephala* (Lam.) de Wit, by feeding on young terminal shoots, causing slow growth or die-back (Fig. 1D), and in severe cases, death of trees. Although considered a weed by some, leucaena is considered a valuable forage crop for cattle by ranchers, who view recent defoliation and die-back as a serious problem. Hence, potential biological control agents are currently being studied by the Hawaii Department of Agriculture. To supplement studies on the control of this insect, an investigation of its biology and reproductive capacity was undertaken.

MATERIALS AND METHODS

Studies were made in the insectary of the Hawaii Department of Agriculture facility under a 12 hr:12 hr photoperiod regimen using Sylvania Grolux fluorescent light. Temperature and humidity were recorded continuously on a Belfort Instrument Co. hygrothermograph. Psyllids were reared on the seedlings of leucaena, grown from seeds collected at the Tantalus area of Honolulu on the island of Oahu. The seedlings were scoured to improve germination (Takahashi and Ripperton 1949) and sprouted in vermiculite.

Seedlings were used in rearing when the cotyledons were fully emerged and the primary leaves were just beginning to unfurl. For rearing nymphs, each seedling was carefully removed from the vermiculite and the hypocotyl

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was rolled in a 2 cm wide strip of moist cotton. The cotton strip was of the proper length to create a roll surrounding the hypocotyl which fit snugly in the mouth of a 2.5 cm diameter plastic vial. In this way the root of the seedling was suspended into the vial which was half-filled with distilled water, while the leaves were held outside the vial, facilitating viewing. Nymphs were prevented from climbing down the hypocotyl by a ring of Tanglefoot placed on the epicotyl just above the cotyledon. For rearing adults, the root of the seedling was clipped to a length of ca. 2 cm, then rolled in moist cotton. The cotton roll surrounding the root was slipped into the bottom of a 4 cm diameter plastic vial so that the seedling fit entirely within the vial. The vial opening was covered with a piece of organza cloth, secured in place by a cap with a ventilation hole.

Studies on the sizes and development times of the immature stages were begun with the egg stage. Eggs were obtained by placing two field-collected females in a vial with a single seedling. In this way 16 eggs were obtained overnight. Of these eggs, 14 developed successfully into 1st-instar nymphs. These nymphs were placed individually with a camel-hair brush on a single leucaena seedling which served as a food source during most of the nymphal period. To obtain data on development, seedlings were examined each day for evidence of molting. When an exuvium was found, it was removed and the day of molting recorded. Width of the head across the eyes was measured for each instar using an ocular micrometer. A small podium of tacky clay was used to hold the vial in a position required to measure the nymphs.

In preparation for development to adults, which are active fliers, 5th-instar nymphs were transferred to single seedlings enclosed in vials. At adulthood, data on fecundity and longevity were obtained by pairing male and female adults within individual vials. Each day, the pair was transferred to a new seedling in a rearing vial and the eggs laid on the old seedling were counted. The transfer was accomplished by immobilizing the pair under refrigeration at 8°C for 15-30 min, then transferring them with a camel-hair brush. To supplement studies on fecundity, 13 additional pairs of adults were reared and used in this part of the study. Data collecting methodology remained the same except for the step on immobilization, which was accomplished by chilling at 0°C for 8-9 min.

RESULTS

Development Rate. Mean laboratory temperature was 25.5°C, ranging from ca. 24° - 27°C, and mean relative humidity was 58%. Under these conditions, development time from egg deposition to adult emergence required 10-11 days (Table 1). Eggs hatched in 2-3 days, and total nymphal period required 8-9 days.

Head Width Measurements. Mean head width, including the eyes, was 0.17 mm for the first instar, increasing with each stage to 0.51 mm for the fifth instar (Table 1). The range of measurements for any one instar did not overlap those of another instar, indicating that this measurement may be used to distinguish the various instars.

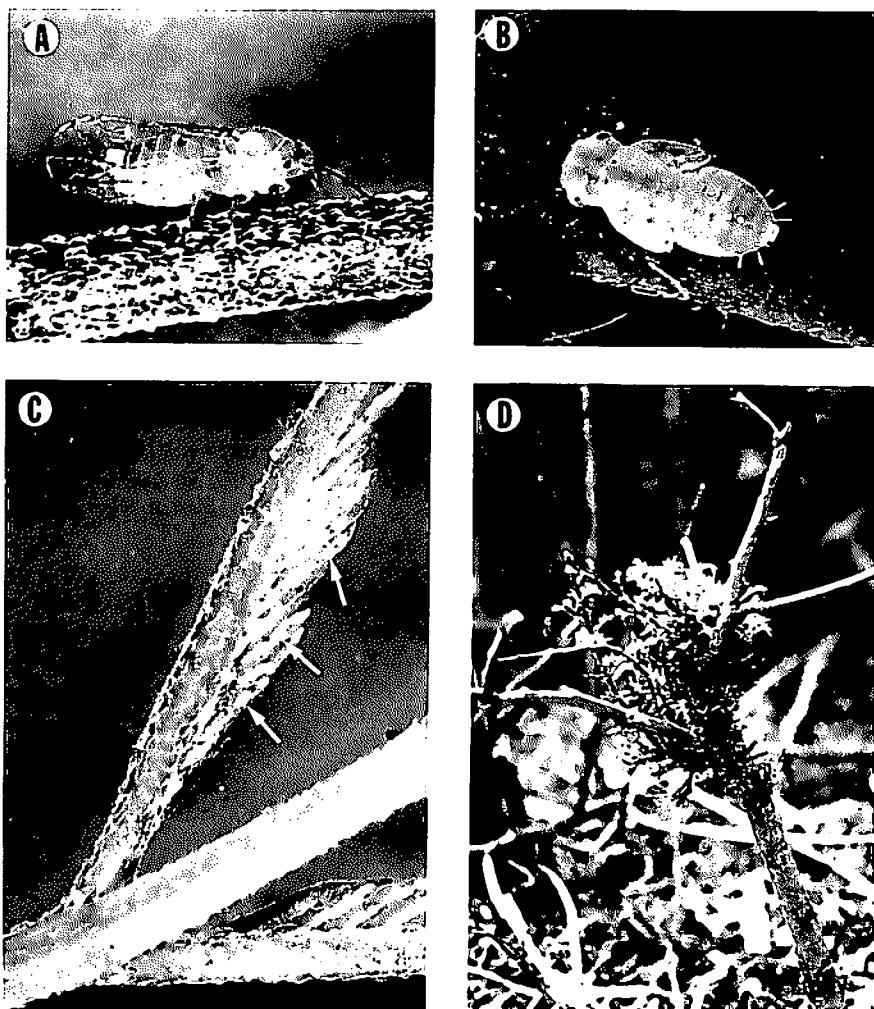


FIGURE 1. *Heteropsylla cubana* Crawford: A, adult; B, late-instar nymph; C, eggs deposited between developing pinnules of leucaena leaf; D, stunting damage to leucaena terminals.

Longevity. Mean adult longevity was 10.6 days for females ($N=20$) and 6.4 days for males ($N=20$). Average life span under natural conditions might be longer than observed in the present study, as it appeared in several cases that death was associated with handling the adults during transfers between vials.

Fecundity. The preoviposition period ranged from 1-3 days. Thereafter, eggs were laid nearly every day until death. Individuals produced as many

as 119 eggs on a single day, the mean among all females being 18.8 per day during the oviposition period. The total number of eggs laid per individual varied from 19 - 857, with a mean of 394.1.

Egg Laying Habits. Eggs were deposited on the plant surface, with a ventral stipe embedded in the plant tissue in a manner typical of psyllids such as *Psylla uncataoides* (Koehler et al. 1966). In addition to serving as an anchor, the stipe may provide moisture to the egg since removal of the egg causes it to shrivel within a day.

The preferred oviposition sites were at the terminals of the bipinnately compound leaves in spaces among the developing pinnae and pinnules (Fig. 1C). In the absence of such sites, eggs were deposited at the base of the pinnae on newly unfurled leaves.

Life Table and Population Growth Statistics. Based on adult female mortality and oviposition records, a life table was constructed (Table 2) in a manner described by Deevey (1947) and Andrewartha and Birch (1954). From this table, statistics describing potential population growth rate were calculated (Table 3). These calculations assumed no mortality in the egg and nymphal stages.

Net reproductive rate, R_0 , was 394.1. This is the factor by which a population would increase during each generation. Thus, a population of leucaena psyllids have the potential to multiply by over 394 times during one generation. Mean generation time, T , the average time required between the birth of a female and the birth of her offspring, was 16.93 days.

Relating this to net reproductive rate, a population may potentially multiply by a factor of 394 approximately every 17 days. The innate capacity for increase, r_m , a factor useful to calculate the potential increase in number of psyllids at any future time, was 0.353. Based upon this figure, it was estimated that a population of psyllids could double in number every 1.96 days.

TABLE 1. Duration and size of immature stages of *H. cubana*. (N=14).

Stage	Duration — days		Head width — mm		
	Mean	Range	Mean	S.D.	Range
Egg	2.1	2-3	—	—	—
1st instar	2.0	None	0.17	0.006	0.16-0.18
2nd instar	1.0	None	0.23	0.009	0.22-0.25
3rd instar	1.7	1-2	0.33	0.014	0.30-0.35
4th instar	1.3	1-2	0.40	0.008	0.39-0.42
5th instar	2.1	2-3	0.51	0.022	0.48-0.52
Total	10.4	10-11	—	—	—

TABLE 2. Life table and age-specific fecundity rates for *H. cubana*. (N=20).¹

X	l_x	d_x	m_x	$l_x m_x$	$l_x m_x X$
0-2/egg	1.00	0	—	—	—
3-10/nymph	1.00	0	—	—	—
11	1.00	0	0.35	0.35	3.85
12	1.00	0	21.40	21.40	256.80
13	1.00	0	40.95	40.95	532.35
14	1.00	0	45.75	45.75	640.50
15	0.95	0.05	47.11	44.75	671.25
16	0.85	0.10	50.41	42.85	685.60
17	0.80	0.50	54.75	43.80	744.60
18	0.65	0.15	58.69	34.90	628.20
19	0.65	0	46.08	29.95	569.05
20	0.50	0.15	69.50	31.75	635.00
21	0.50	0	46.80	23.40	491.40
22	0.40	0.10	35.75	14.30	314.60
23	0.30	0.10	26.17	7.85	180.55
24	0.20	0.10	15.50	3.10	74.40
25	0.20	0	12.00	2.40	60.00
26	0.10	0.10	14.00	1.40	36.40
27	0.10	0	16.50	1.65	44.55
28	0.10	0	13.50	1.35	37.80
29	0.10	0	2.00	0.20	5.80
30	0.10	0	10.00	1.00	30.00
31	0.10	0.10	10.00	1.00	0.31
			$R_0 =$	394.10	6673.70

¹X = age in days; l_x = proportion of adult females surviving to age X; d_x = proportion of adult females dying during the Xth day; m_x = average no. of eggs laid per surviving female; $l_x m_x$ = the product of l_x and m_x ; $l_x m_x X$ = the product of l_x , m_x and X.

TABLE 3. Population growth statistics of *H. cubana*, assuming no mortality during egg and nymphal stages.

Population growth statistic	Symbol	Formula	Value
Net-reproduction rate	R_0	$l_x m_x$	394.1
Mean generation time	T	$\frac{l_x m_x X}{l_x m_x}$	16.93 days
Innate capacity for increase	r_m	$\frac{\log_e R_0}{T}$	0.353
Population doubling time	DT	$\frac{\log_2}{r_m}$	1.96 days

DISCUSSION

Population growth statistics reported herein give some indication of the reproductive potential of the leucaena psyllid. In nature, numerous factors may modify this potential upward or downward. For instance, higher than laboratory temperatures would increase development rate, thus shortening mean generation time, T , and increasing the innate capacity for increase, r_m . Cooler temperatures would slow development rate and have the opposite effect on population growth.

It should also be pointed out that no reductive forces except unidentified sources of adult mortality in the laboratory have been considered in calculating the population growth statistics. In nature, numerous mortality factors reduce the rate of growth indicated by the population growth statistics.

Catling (1969) reported that population fluctuations of the citrus psylla, *Trioza erytreae* (Del Guercio), were primarily influenced by the flushing rhythms of its citrus host, weather (moisture and temperature), and natural enemies. Other governing factors included inter- and intraspecific competition, and tree variety and condition.

Similar factors have influenced leucaena psyllid populations in Hawaii after the early period of explosive growth. Of these many elements, the availability of flush growth appears to be an important factor in determining leucaena psyllid numbers. A flush cycle initiates a rapid buildup of psyllids that may reach dense populations. Intraspecific competition then contributes to a decline in psyllid numbers; egg mortality is caused by the necrosis of young shoots due to heavy feeding, and deaths of nymphs and adults occur because of lack of food and entanglement in their own honeydew secretions. Overcrowding and the scarcity of breeding sites also prevent *H. cubana* from realizing its reproductive potential.

Rainfall will stimulate leucaena to flush. Moisture and season of the year are primary factors influencing the growth rate of leucaena (Kinch and Ripperton 1962). Leucaena is well adapted to Hawaiian conditions; however, it requires adequate water for good growth. During the low rainfall summer months, plant growth is poor despite warmer temperatures and longer days. Some older foliage is sustained on the plant, but most leaves are shed and new growth is not produced. During the wetter winter season, leucaena will flush in response to heavy rainfall. Production of new terminal growth provides an abundance of ovipositional sites for psyllids.

Control of *H. cubana* by locally established natural enemies has been only partially effective. Of those observed attacking the psyllid, the coccinellid beetle, *Curinus coeruleus* Mulsant, appears to be the most important. This general predator has exerted some control in the field; however, it has failed to respond quickly to increasing psyllid populations. Serious plant injury has continued to occur when psyllids attack new flush growth. Population increases of the predator typically lag behind those of the psyllid during such episodes. Only after an extended period of high prey density does *C. coeruleus* become effective. Another coccinellid beetle, *Olla ab-*

dominalis Say, has been found commonly associated with psyllid infestations. However, control by this predator is thought to be compromised by attack from non-beneficial parasites.

Effective biological control of *H. cubana* would theoretically require the introduction of a natural enemy possessing the attributes of the ideal parasitoid, but specifically having the ability to maintain psyllid numbers at low levels at the start of a flush cycle. Locally established coccinellids may provide supplemental control if an outbreak occurs; however, the required host levels for reproducing populations of these predators are not known. A complex of factors influence psyllid populations, and each of these elements should be further studied to determine their relationships.

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